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Research Article

Scientific Literacy Assessment Using Bybee's Scientific Model: Towards a More Sustainable Science Education

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About Article

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ABSTRACT

This research addressed an important gap in evaluating the scientific literacy of freshmen college students, an area that has yet to be fully explored and requires deeper investigation. Scientific Literacy is a form of literacy that dwells on a person's ability to understand scientific concepts and relate it to real life. In this study, the use of Bybee's four scientific literacy dimensions (nominal, functional, conceptual, and multidimensional level) were used to assess the scientific literacy of freshmen college students. The use of descriptive-quantitative research design was used to attain the general objective of this study. A validated 72-item questionnaire was implemented to 407 respondents who are officially enrolled in the SY 2023-2024. In analyzing the data, the use of percentage, mean, and Kruskall-Wallis H tests were utilized. Results of the overall scientific literacy level can be interpreted as "did not meet expectations" for both life science and physical science. In addition, all levels of four scientific literacy based on Bybee's scale are also interpreted as "did not meet expectations". Findings also revealed that respondents experienced much lower performance in physical sciences compared to life science in the overall scientific literacy, nominal, functional, and conceptual levels. When analyzed by gender, data shows statistically significant differences in the overall life science scientific literacy and overall nominal and functional literacy. However, when further analyzed, gender shows a statistically significant difference in physical sciences in both nominal and functional literacy. In terms of strands, data shows no statistically significant difference. Thus, the findings of the study suggest an enhancement program to alleviate the current status of scientific literacy among freshmen students. In addition, a reform in the current strategies and curriculum should also be considered as part of delivering scientific literacy among learners.

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1. INTRODUCTION

Being scientifically literate is having the ability to understand, interpret, and engage with scientific concepts and processes. This literacy is highly important since this can be used in daily life and is crucial to the needs and demands of modern society (Stefanski *et al.*, 2019). Even though extensive literature exists about assessing science literacy, however majority of the literature focuses on basic education such as elementary and secondary level (Snow & Dibner, 2016). The ability of Higher Education Institutions (HEI) as an academe to mold and enhance students' learning is crucial to developing competent learners (OECD, 2017). To ensure this, an assessment of the level of scientific literacy of students from various programs in higher education is important and serve as a tool to enhance an individual's ability that have a greater impact on society (Ajayi, 2018). Therefore, assessing scientific literacy at the early stage in college/university can be a great help in preparing students for modern society better.

Students' abilities in science and technology should be developed through science education, especially the capacity to overcome obstacles, make choices, and acquire life skills effectively in the 21st century's global community (Turiman *et al.*, 2012). 21st Century are helpful in attaining relevant skills necessary for learners (Diez *et al.*, 2021; Diquito, 2024). However, some studies indicate gender bias relating to cognitive achievement and skill development. Gender disparities appear in academic ability, verbal , and GPA (Tsaousis & Alghamdi, 2022). These factors would probably affect students' learning activities and social activities. Meanwhile, Tiwari (2021) states that the educational system places a high priority on students' Senior High School academic performance. However, only a few numbers of studies have examined how the academic strand affects the academic performance of students, particularly in the area of science (Rubas, 2023).

Several countries attempt to make scientific literacy the primary purpose of schooling. Knowledge of scientific concepts and methods, as well as their consideration, are crucial for independent judgment, participation in racial and social issues, and economic productivity. Therefore, being scientifically educated is crucial because science permeates all aspects of our lives (Ajayi, 2018). The OECD (2024) conducts global longitudinal studies using written tests and questionnaires. Achieving these objectives reveals that developing nations perform poorly overall. In the United Kingdom, science education is required for citizens with an age of four to sixteen years (Osborne, 2013). In line with this, the Malaysian national curriculum includes science as a fundamental subject in both the elementary and secondary school curricula, covering physics, biology, chemistry, and other sciences (Mat Noor, 2021). In addition, Webb (2010), have mentioned that African pupils have a low degree of science literacy. Moreover, the difficulties of teaching science were listed in a study of high school science instructors in Kenya, which included, among other things, the shortage of competent scientific teachers. Overall, improving science literacy calls for addressing each information gaps is covered in advanced nations and the systematic demanding situations faced in developing areas.

In the Philippines, notable differences in scientific knowledge and application among Philippine college students are being documented. Palines and Ortega-Dela Cruz (2021) found out that although most students had a basic understanding of scientific principles, there were noticeable gaps in their capacity to apply these concepts to real-world problems. In addition, Gormally *et al.* (2009) polled 250 students at multiple Philippine colleges and discovered that while science literacy was moderate, there were inadequacies in critical reasoning and ability to solve problems. This study has two major factors that have a big impact on scientific education in the Philippines. First, studies by Makarova *et al.* (2019) have shown that gender stereotypes still exist in Science, Technology, Engineering, and Mathematics (STEM) disciplines, which discourages female students from choosing professions in science because of cultural expectations. Second, as evidenced by research conducted by Rafanan *et al.* (2020) the choice of Senior High School (SHS) strands, particularly the STEM strand, might affect the outcomes of science education. STEM students perform higher on national exams linked to science.

In a study conducted by Genç (2015), the results show that the science literacy of General Academic Strand (GAS) students has no significant difference when it comes to gender. Students' misunderstandings of natural laws, theories, hypotheses, and the scientific method were conclusively determined to be low. In addition, Farillon (2022), mentioned that when SHS students were grouped by strand, the STEM, GAS, and Accountancy, Business, and Management (ABM) were found to have the highest levels of scientific reasoning skills, whereas the Technical Vocational Track (TVL) tracks had an average degree of critical thinking abilities. When it comes to scientific performance, academic tracks are at a very satisfactory level. This variation of scientific literacy among various strands signifies that there is still a gap of scientific literacy among Filipino learners.

Further, this study is conducted to assess the scientific literacy of freshmen college students. The findings of the study are helpful to educators, administrators, students, stakeholders, and policymakers on how to approach scientific literacy. This way, all students are given the opportunity to acquire the scientific literacy needed in modern society. Therefore, this study is guided with the following objectives; (1) determine the profile of the respondents in terms of gender and strand graduated; (2) determine the level of scientific literacy of freshmen students based on the following dimensions: 2.1. nominal level, 2.2. functional, 2.3. conceptual, and 2.4. multidimensional; and (3) determine if there is a significant difference in scientific literacy when analyzed by profile.

2. LITERATURE REVIEW

Scientific literacy is a broad concept that encompasses multiple dimensions. For example, the National Academies of Sciences, Engineering, and Medicine (2016) define this concept as the process of knowing and creating with the practice of science. In addition, the OECD (2023) defined this concept as actively participating in discussions on sustainability, science, and technology. Moreover, science is a broad discipline that comprises multiple disciplines, such as biology, physics, chemistry, and earth science, to name a few. Each discipline has unique topics that may contribute to attaining scientific literacy (Kurt, 2021; Opitz *et al.*, 2017). Some fields may also cross with other fields, resulting in a much more complexity of the discipline (Geelhaar, 2014; Mantegna, 2024; Rodríguez-Muñoz & Huincahue, 2024). Thus, understanding how scientific literacy develops among learners and the contributing factors of this development is necessary.

Bybee (1997) developed a framework for scientific literacy consisting of four levels: nominal, functional, conceptual, and multidimensional. In addition, Uno and Bybee (1994) defined these levels as follows: Students can identify scientific terms at the nominal level but often have an inaccurate understanding of specific topics. Functional scientific literacy involves students correctly describing concepts, though their comprehension remains limited. At the conceptual level, students grasp the main conceptual frameworks of science and apply them to their broader understanding of the subject. This level also includes knowledge of scientific procedures, procedural skills, and technological advancements. The multidimensional level of scientific literacy extends beyond disciplinary knowledge and methods of scientific inquiry to include social, historical, and philosophical aspects of science and technology. Students at this level gain an appreciation for how science and technology relate to their everyday lives, drawing connections between scientific fields, research, technology, and significant societal issues.

Several studies assess students' scientific literacy using Bybee's scale. For example, a study conducted by Al-Momani (2016) found that students achieved low scientific literacy in their early college years and later improved. In addition, it is also found that students are more standout in functional literacy. The same finding is also documented by Shahzadi and Nasreen (2020) wherein secondary-level students only attained nominal and functional literacy and further found out that girls performed better than boys. Moreover, Anakara (2021) also found that students have a high level of nominal literacy but however low level of multidimensional literacy. These previous studies suggest that most students achieved either nominal or functional literacy but a low level of literacy at conceptual or multidimensional levels. Thus, conducting a similar study in a different context may add discussion of previous literature.

3. METHODOLOGY

3.1. Research Design

This study utilizes a Quantitative Research Design employing descriptive methodology. Creswell (2005) defined quantitative research as a method for testing objective theories by examining the relationship between variables. These variables, in turn, can typically be measured using instruments, resulting in a number of data that can be analyzed statistically. Furthermore, Siedlecki (2020) stated that descriptive research involves description, analysis, and interpretation of the data. Therefore, this design is used to determine the scientific literacy of freshmen students following Bybee's scientific literacy scale.

3.2. Respondents

This study was conducted at the University of Mindanao, specifically the UM Digos College located in the province of Davao del Sur, Philippines (Acuña *et al.*, 2021). Currently, the college has a total of 4200 students (SY 2023-2024), wherein more than 2000 of the population are freshmen students. Moreover, the respondents of the study are first-year college students who were purposely chosen as the respondents of the study since these groups of learners are still new to the university and products of basic education in the Philippines. In addition, the use of stratified sampling was used to determine the sample of the respondents. In this study, the researchers specifically targeted the department of which the students are enrolled as the strata. This is done to ensure that there are a variety of characteristics in the population that could influence the study's conclusion (Elfil & Negida, 2017).

To ensure that the respondents are properly selected the research is guided by the following inclusion criteria:

(1) must be officially enrolled in the academic year 2023-2024,

(2) must be 1st year,

(3) and willing to participate in the study. The participants were selected to ensure that different groups within the population were fairly represented in the study. This method allows for more reliable and balanced results by considering key differences among students.

Table 1. Demographic Profile of the Respondents (n=407)

Departments	No. of Respondents
Department of Arts and Sciences (DAS)	31
Department of Accounting Education (DAE)	11
Department of Business Administration (DBA)	69
Department of Technical Program (DTP)	17
Department of Criminal Justice Education (DCJE)	208
Department of Teacher Education (DTE)	71

3.3. Instrument

In this study, the researchers developed a research-made questionnaire that consisted of two sections. The first section contains information about the student's demographic profile, such as the gender, program, name (optional), and Senior high school strand graduated. The second section contains multiple-choice questions assessing the knowledge of students on science, which is considered the core science subject in the Senior high school of the K-to-12 program of the Department of Education (Department of Education, 2016). According to Johnson & Martin-Hansen (2005) core science subjects consist of word problems, experimentation, concepts, research, and inquiries of results to compare with their other classmates. Also, this researcher-made test utilized Bybee's scientific literacy scale to determine the level of science literacy among the respondents. It is divided into four levels: nominal level where students can recognize scientific terms but often misunderstand the underlying concepts, functional level where students can describe concepts correctly but comprehension is poor, conceptual level where students can grasp and apply key scientific concepts and methods, and multidimensional level where students can go beyond ideas related to scientific disciplines and methods of scientific inquiry. They start to draw linkages across scientific fields between research, technology, and more importantly, societal problems.

Moreover, the researchers formulated a Table of Specifications (TOS) of the 72-item questionnaire to determine the areas of achievement being assessed and to make sure a fair and representative sample of questions is included on the test. In this study, following the Revised Blooms Taxonomy developed by Anderson & Krathwohl (2001). The TOS being used focuses only on the Remembering (Rem), Understanding (Und), and Analyzing (Ana) levels (see Table 2). Anderson & Krathwohl (2001) described remembering (Rem) as the ability to recall information from memory, understanding (Und) refers to the ability to construct meaning, and analyzing (Ana) which determine how different concepts relate to one another. To ensure comprehensive coverage of scientific literacy, the Table of Specifications (TOS) was carefully designed to align with these cognitive levels. This approach not only guarantees that a balanced range of skills is assessed but also reflects the complexity of student understanding (Olores *et al.*, 2023).

The focus on these specific levels allows researchers to evaluate students' ability to retain knowledge, comprehend concepts, and make connections between scientific ideas, providing a thorough assessment of their literacy skills. This method ensures that the test measures different levels of thinking, from simple recall to deeper understanding and analysis. By focusing on these areas, the researchers can get a clearer picture of how well students grasp and apply scientific ideas.

The created researcher-made questionnaire undergoes content validation using the Lawshe method (Lawshe, 1975). Content validation refers to a process that aims to assure that an instrument (checklist, questionnaire, or scale) measures the content area it is expected to measure (Ayre & Scally, 2014). Lawshe's method has been widely used to establish and quantify content validity. In this study, there are Eleven (11) experts in the field of science education validated the constructed items along with the table of specifications. Based on the result, it was revealed that all items exceed the critical value (0.59) needed to accept the items for 11 experts. Also, there are minor revisions that were carried out based on the expert's recommendation. The validation process confirmed that the questionnaire items were appropriate for assessing the intended scientific literacy content. The feedback from experts helped refine the instrument, ensuring it aligns with the study's goals and improves the overall accuracy of data collection. The experts' feedback ensured that the questionnaire was both clear and effective in measuring what it was designed to assess.

Table 2. Table of Specifications of the Questionnaire

Topic	Dimension	Level	Distribution		Item Numbers
			%	items	
Physical Science	Nominal Scientific Literacy	Rem	12.5%	9	1, 2, 3
		Und			4, 5, 6
		Anal			7, 8, 9
	Functional Scientific Literacy	Rem	12.5%	9	10, 11, 12
		Und			13, 14, 15
		Anal			16, 17, 18
	Conceptual Scientific Literacy	Rem	12.5%	9	19, 20, 21
		Und			22, 23, 24
		Anal			25, 26, 27
	Multidimensional Scientific Literacy	Rem	12.5%	9	28, 29, 30
		Und			31, 32, 33
		Anal			34, 35, 36
Life Science	Nominal Scientific Literacy	Rem	12.5%	9	37, 38, 39
		Und			40, 41, 42
		Anal			43, 44, 45
	Functional Scientific Literacy	Rem	12.5%	9	46, 47, 48
		Und			49, 50, 51
		Anal			52, 53, 54
	Conceptual Scientific Literacy	Rem	12.5%	9	55, 56, 57
		Und			58, 59, 60
		Anal			61, 62, 63

	Multidimensional Scientific Literacy	Rem	12.5%	9	64, 65, 66
		Und			67, 68, 69
		Anal			70, 71, 72
Total			**100%**	**72**	**72**

3.4. Procedure and Data Analysis

To complete this study, the researchers followed several key procedures. The researchers submitted a formal request seeking permission from the Dean of College at UM Digos College. This request aimed to ensure the legitimacy of the study and secure authorization to conduct research activities within the campus. Upon receiving approval, the researchers administered a thoroughly tested and validated questionnaire as the primary research instrument during the data collection phase. This phase was conducted under strict guidelines to maintain consistency and reliability. After the completion of data collection, each respondent's responses were meticulously checked and scored by the researchers. These scores were then systematically entered into an Excel spreadsheet, organizing the data efficiently for subsequent statistical analysis to interpret the results.

In addition, percentage, mean, SD, and Kruskal Wallis H-Test statistical tools were used in the analysis. Percentage, mean, and SD were used to determine the level of scientific literacy among freshmen students. Moreover, in the analysis of percentage, the researchers used the scale provided by the Department of Education in the Philippines (see Table 3) (Department of Education, 2015). In addition, the use of Kruskal Wallis H-Test is also used in this study to determine if there is a significant difference of scientific literacy among freshmen students when analyzed by profile. According to (Kruskal & Wallis, 1952) this test is based on the analysis of independent random samples from each of the k populations. In this study, the Kruskal Wallis H-test is used to determine if there is a significant difference in scientific literacy when analyzed by the profile of the respondents. These statistical tools helped make sense of the data and allowed for an accurate comparison between groups.

Table 3. Scale and Description (Department of Education, 2015)

Scale	Description
100.00 - 90.00	Outstanding (O)
89.00 - 85.00	Very Satisfactory (VS)
84.00 - 80.00	Satisfactory (S)
79.00 - 75.00	Fairly Satisfactory (FS)
Below 75.00	Did Not Meet Expectations (DE)

4. RESULTS AND DISCUSSION

4.1. Profile of Respondents

Table 4 shows the profile of four hundred seven (407) respondents of the study. In terms of gender, data shows that female comprises the majority of respondents (f=228, %=56.00) over males (f=179, %=44.00). In terms of the track during their Senior High School (SHS) days, the majority of the respondents come from the Humanities and Social Sciences (HUMSS) (f=169, %=41.50) followed by General Academic Strand (GAS) (f=72, %=17.70), Technical Vocational Livelihood (TVL) (f=65, %=16.00), Accountancy, Business, and Management (ABM) (f=56, %=13.80), and Science, Technology, Engineering, and Mathematics (STEM) (f=45, %=11.10) respectively.

Table 4. Profile of Respondents (n=407)

Group	Strand	Frequency (f)	Percentage (%)
Gender	Male	179	44.00
	Female	228	56.00
Strand	ABM	56	13.80
	HUMSS	169	41.50
	STEM	45	11.10
	GAS	72	17.70
	TVL	65	16.00

4.2. Scientific Literacy of Freshmen Students Based on Bybee's Scale

Table 5 shows the scientific literacy of 1st-year students who graduated in the K-12 curriculum. Data shows that respondents' overall scientific literacy level can be interpreted as "Did Not Meet Expectations" (%=35.35, SD=14.57). This means that this group of learners failed to attain an overall scientific literacy based on the Department of Education (2015) interpretation. This data is also can be observed on both overall performance in life science (%=34.47, SD=15.13) and physical science (%=32.22, SD=16.68). In addition, the result of the performance of respondents in Bybee's scale indicates similar findings of "Did Not Meet Expectations" for each level. However, it can be observed that respondents obtained a higher performance on the nominal scale compared with other scales. In addition, respondents obtained a lower performance on the multidimensional scale compared with other scales. Moreover, data also shows that respondents obtained a much lower performance in physical science compared to life science (with the exception of the multidimensional level). This suggests that respondents perform more in life science compared to the physical sciences.

Table 5. Level of Scientific Literacy of Respondents Based on Bybee's (1997) Scientific Literacy Framework per Cluster

Scale	Subject Area	Performance (%)	SD	Interpretation
Nominal	Life Science	48.81	26.23	DE
	Physical Science	41.50	30.46	DE
	Overall	45.15	23.48	DE
Functional	Life Science	40.19	26.27	DE
	Physical Science	37.59	19.36	DE
	Overall	38.89	19.71	DE
Conceptual	Life Science	32.48	19.93	DE
	Physical Science	31.93	18.03	DE
	Overall	32.20	16.04	DE
Multidimensional	Life Science	23.42	18.32	DE
	Physical Science	26.89	20.66	DE
	Overall	25.85	16.85	DE
Overall	Life Science	34.47	15.13	DE
	Physical Science	32.22	16.68	DE
	Overall	35.35	14.57	DE

The findings of the study support various literature across different countries pertaining to low level of scientific literacy. Studies include Baltikian *et al.* (2024) in Lebanon, Bernardo *et al.* (2023) in the Philippines, and Suroso *et al.* (2021) in East Java, Indonesia to name a few. This shows that scientific literacy is also an issue in other areas across the globe. In addition, it is being observed that among the four levels of scientific literacy, the most difficult to attain is multidimensional. This finding is also similar to the findings of Shahzadi & Nasreen (2020) that only a few students have acquired this level of scientific literacy, and most of the students attained the nominal and functional level. Moreover, The results support Gaigher *et al.* (2007) which stated that students often struggle with learning physics. They face difficulties in understanding key concepts and principles, and even with extensive practice, solving problems accurately remains a challenge. Some students may also solve problems without fully grasping the underlying physics concepts. This aligns with Kuo *et al.* (2013) findings, which emphasize that students often struggle to link abstract theories to real-world contexts, impacting their problem-solving abilities. Furthermore, Bigozzi *et al.* (2018) noted that despite various teaching approaches, the inherent complexity of physics continues to pose significant challenges for students, particularly in achieving conceptual understanding.

According to Ardianto and Rubini (2016), factors like school infrastructure, faculty quality, and school management contribute to this issue. Additionally, insufficient resources and outdated teaching methods hinder students' ability to fully engage with scientific concepts. Without proper support and resources, students may continue to struggle with scientific literacy throughout their academic journey. This lack of engagement can lead to gaps in understanding, making it harder for students to grasp more complex scientific topics. As a result, students may develop negative attitudes toward science, further impacting their performance. Addressing these issues is crucial to improving overall scientific literacy in education systems. Ngozi & Halima (2015) argue that inadequate resources and poor facilities significantly hinder students' science education by limiting access to essential tools and hands-on learning experiences. Without modern laboratory equipment, updated textbooks, and sufficient learning materials, students miss out on crucial practical applications of scientific concepts. Similarly, Bernardo *et al.* (2023) highlights those disparities in educational resources and teaching quality lead to differences in students' scientific literacy.

4.3. Differences in Scientific Literacy Among Freshmen Students when Analyzed by Gender

Table 6 shows the difference in respondent's overall scientific literacy when analyzed by gender. The table showed that there is no significant difference between male (mean rank = 192.38, Sum of ranks = 34435.5) and female (mean rank = 213.13, Sum of ranks = 48592.5) respondent's overall scientific literacy, (Mann-Whitney U (407) = 18325.5, p =.077). This means that regardless of gender, respondents obtained a similar level of overall scientific literacy. However, the overall life science scientific literacy exhibited a significant difference when analyzed by gender (Mann-Whitney U (407) = 17628, p =.018). This means that gender plays a role in learning life science. In addition, the overall nominal scale (U (407) = 17364.5, p = 0.010) and overall functional scale (U (407) = 17291.5, p = 0.008) show significant difference when analyzed by gender. This shows that gender play a role in attaining these scientific literacy scales. However, when further analyzed, only the physical science in both the nominal scale (U (407) = 16761.5, p = 0.002) and functional scale (U (407) = 15990, p = 0.000) exhibit a significant difference when analyzed by gender. This means that physical science has a significant impact on attaining nominal and functional scale based on gender.

Table 6. Differences in Scientific Literacy among the Respondents when Analyzed by Gender using Mann-Whitney U Test

Variables	Subject	Group	Mean Rank	Sum of Ranks	Mann Whitney	Z	Asym. Sig
Nominal Scientific Literacy	Physical Science	Male	183.64	32871.5			
		Female	219	50156.5			
		Total			16761.5	-3.119	0.002*
	Life Science	Male	193.3	34601			
		Female	212	48427			
		Total			18491	-1.646	0.100
	Overall	Male	187.01	33474.5			
		Female	217.34	49553.5			
		Total			17364.5	-2.591	0.010*
Functional Scientific Literacy	Physical Science	Male	179.33	32100			
		Female	223.37	50928			
		Total			15990	-3.783	0.000*
	Life Science	Male	202.59	36264			
		Female	205.11	46764			
		Total			20154	-0.217	0.828
	Overall	Male	186.6	33401.5			
		Female	217.66	49626.5			
		Total			17291.5	-2.654	0.008*
Conceptual Scientific Literacy	Physical Science	Male	205.99	36872.5			
		Female	202.44	46155.5			
		Total			2049.5	-0.307	0.759
	Life Science	Male	196.47	35167.5			
		Female	209.91	47860.5			
		Total			19057.5	-1.166	0.244
	Overall	Male	202.62	36269			
		Female	205.08	46759			
		Total			20159	-0.211	0.833
Multidimensional Scientific Literacy	Physical Science	Male	206.91	37037.5			
		Female	201.71	45990.5			
		Total			19884.5	-0.451	0.652
	Life Science	Male	206.91	37037.5			
		Female	201.71	45990.5			
		Total			18994.5	-1.221	0.222
	Overall	Male	200.81	35944.5			
		Female	206.51	47083.5			
		Total			19834.5	-0.488	0.626

Overall Scientific Literacy	Physical Science	Male	196.11	35104.5			
		Female	210.19	47923.5			
		Total			19041.5	-1.161	0.246
	Life Science	Male	200.81	35944.5			
		Female	206.51	47083.5			
		Total			17628.0	-2.362	0.018*
	Overall	Male	192.38	3435.5			
		Female	213.13	48592.5			
		Total			18325.5	-1.767	0.077

*Note: p<.05**

The findings of the study is supported on various literature pertaining on the influence of gender in scientific literacy. Hardinata *et al.* (2019) found that both male and female students show similar levels of scientific literacy, but many still face challenges in fully understanding and applying scientific concepts. This suggests that other factors, beyond gender, may influence students' ability to grasp science. For example, Abdi (2014) argues that teaching methods significantly impact how students engage with science, noting that hands-on and inquiry-based approaches tend to enhance comprehension. Additionally, a study by Xu & Ouyang (2022) highlights that access to resources, including lab materials and technology, plays a crucial role in students' ability to learn and apply science in real-world contexts. Without addressing these educational and contextual factors, improving scientific literacy may remain a challenge.

Moreover, gender affects how well students learn life science. Britner (2008) found that while there were no differences between boys and girls in physical science grades or confidence, girls in life science classes often got higher grades but felt less confident and more anxious about science than boys. Similarly, Graves *et al.* (2021) showed that girls usually perform better in life science but deal with more stress and lower confidence compared to boys. Garber *et al.* (2016) also found that although girls might score higher in some science subjects, they often struggle with self-confidence and anxiety, which impacts their learning experience. These findings suggest that while nominal and functional scientific literacy differs by gender, Čipková *et al.* (2020) reported that gender does not significantly affect scientific literacy levels, highlighting discrepancies between different studies.

However, the findings contradict those of Shahzadi & Nasreen (2020) and Istiyono *et al.* (2019) who suggest that girls outperform boys. According to Shahzadi & Nasreen (2020), girls exhibit traits such as self-regulation, discipline, hard work, and perseverance, all of which are crucial for achieving high literacy levels. Conversely, Caselman *et al.* (2006) found that girls scored lower than boys in scientific literacy. Analysis of PISA reports from 2000, 2003, and 2006 revealed significant gender disparities in scientific literacy levels, with Finland being the only country where girls were expected to outperform boys (OECD, 2024).

4.4. Differences in Scientific Literacy Among Freshmen Students when Analyzed by Strand

Table 7 shows the Kruskal-Wallis H Test among the graduated track of the respondents. Data shows that there is no significant difference in the scientific literacies when analyzed by track graduated ($\chi2= 4.312$, $p = 0.365$). This result indicates that regardless of students' track in their Senior High School (SHS) school days, their scientific literacy is the same (both physical science and life science). In addition, data also shows that when analyzed per Bybee's scale, respondents' scientific scale shows no significant difference. This means that regardless of the respondent's track, their scientific literacy based on Bybee's scale is similar.

Table 7. Differences in Scientific Literacy Among the Respondents When Analyzed Track Graduated Using Kruskal Wallis H-Test

Variables	Subject	Group	N	Mean Rank	Chi-square	Df	Asym. Sig
Nominal Scientific Literacy	Physical Science	ABM	56	227.26	6.485	4	0.166
		HUMSS	169	192.54			
		STEM	45	228.57			
		GAS	72	207.36			
		TVL	65	193.02			
		Total	407				

	Life Science	ABM	56	203.51	2.962	4	0.564
		HUMSS	169	197.25			
		STEM	45	218.13			
		GAS	72	219.71			
		TVL	65	194.79			
		Total	407				
	Overall	ABM	56	222.33	5.919	4	0.205
		HUMSS	169	192.28			
		STEM	45	226.81			
		GAS	72	213.7			
		TVL	65	192.15			
		Total	407				
Functional Scientific Literacy	Physical Science	ABM	56	22.61	6.739	4	0.150
		HUMSS	169	192.14			
		STEM	45	216.8			
		GAS	72	223.05			
		TVL	65	188.85			
		Total	407				
	Life Science	ABM	56	193.13	6.088	4	0.193
		HUMSS	169	191.48			
		STEM	45	225.29			
		GAS	72	222.87			
		TVL	65	210.28			
		Total	407				
	Overall	ABM	56	209.8	6.260	4	0.180
		HUMSS	169	190.36			
		STEM	45	221.54			
		GAS	72	226.4			
		TVL	65	197.5			
		Total	407				
Conceptual Scientific Literacy	Physical Science	ABM	56	189.21	3.417	4	0.491
		HUMSS	169	198.32			
		STEM	45	223.59			
		GAS	72	204.81			
		TVL	65	217.04			
		Total	407				
	Life Science	ABM	56	170.44	7.05	4	0.133
		HUMSS	169	202.9			
		STEM	45	202.64			
		GAS	72	227.51			
		TVL	65	208.78			
		Total	407				

	Overall	ABM	56	176.26	5.167	4	0.271
		HUMSS	169	200.53			
		STEM	45	218.13			
		GAS	72	238.57			
		TVL	65	215.45			
		Total	407				
Multidimensional Scientific Literacy	Physical Science	ABM	56	179.76	7.435	4	0.115
		HUMSS	169	198.35			
		STEM	45	238.57			
		GAS	72	213.74			
		TVL	65	204.85			
		Total	407				
	Life Science	ABM	56	185.55	2.027	4	0.731
		HUMSS	169	203.12			
		STEM	45	212.09			
		GAS	72	209.64			
		TVL	65	210.33			
		Total	407				
	Overall	ABM	56	179.11	4.879	4	0.300
		HUMSS	169	200.39			
		STEM	45	225.64			
		GAS	72	214.15			
		TVL	65	208.59			
		Total	407				
Overall Scientific Literacy	Overall Physical Science	ABM	56	184.12	4.917	4	0.296
		HUMSS	169	197.38			
		STEM	45	217.32			
		GAS	72	224.35			
		TVL	65	206.57			
		Total	407				
	Overall Life Science	ABM	56	206.71	4.855	4	0.302
		HUMSS	169	192.76			
		STEM	45	230.83			
		GAS	72	216.34			
		TVL	65	198.64			
		TOTAL	407				
	Overall	ABM	56	198.29	4.312	4	0.365
		HUMSS	169	194.04			
		STEM	45	227.2			
		GAS	72	219.15			
		TVL	65	201.96			
		TOTAL	407				

Note: $p<.05^*$

The findings of the study suggest that regardless of strand graduated, students' scientific literacy is the same. Moreover, it can be noted that other factors play a crucial role in the development of scientific literacy. These factors include social experiences in school, metacognitive awareness of reading strategies, characteristics, and access to ICT with internet connections to name a few (Bernardo *et al.*, 2023). In addition, Osborne (2013) found that many students lose interest in science as they progress through school, often seeing it as irrelevant to their lives. Moreover, science learning anxiety is another consideration to look for (Degorio *et al.*, 2023). Formative assessment also need to be consider when analyzing the competency level of learners (Languita *et al.*, 2023). Similarly, Hoban *et al.* (2015) suggest that the way science is taught, focusing on memorization rather than inquiry, contributes to students' disengagement and lack of deeper understanding of scientific topics. Therefore, these factors can be a contributing factor to why students have similar levels of scientific literacy when analyzed by strand.

5. CONCLUSION

This study aimed at assessing the level of scientific literacy among first-year college students based on Bybee's (1997) four dimensions of scientific literacy. In addition, this study dwells as well in understanding the factors that influence it such as gender and graduated strand. Following a comprehensive analysis of the underlying issue, it was found that the overall scientific literacy is interpreted as "Did Not Meet the Expectations". Thus, this implies that the current freshmen students demonstrate a low level of scientific literacy in all four dimensions. Moreover, when analyzed by gender, both males and females show a statistically significant difference in nominal and functional literacy. This suggests that gender plays a role in the formulation of scientific literacy at both levels. However, it can be noted that this significant difference is only applicable to the physical sciences further implying that gender plays a role in learning physical sciences. When analyzed by graduated strand, data shows no significant difference, implying that regardless of track graduated, respondents' scientific literacy is the same. Moreover, based on the gathered data it is suggested to have a deeper look into conceptual understanding and multidimensional learning, compared to nominal and practical aspects, exposes several gaps in student comprehension. Thus, further suggesting to implement strategies aimed at enhancing students' conceptual understanding and multidimensional learning. This could involve revising the curriculum to incorporate more active teaching methods, such as hands-on experiments and the application of scientific concepts to real-world scenarios. Integrating scientific literacy more explicitly into course syllabi will also help ensure that students develop a stronger foundation in scientific thinking.

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